AD-A162 478 ON MINI CONFERENCE ON ORDER RESTRICTED INFERENCE HELD AT IOWA UNIVERSITY CAMPUS ON 11-13 SEPTEMBER 1985(U) IOWA UNIV IOWA CITY R DYKSTRA ET AL. NOV 85 1/1

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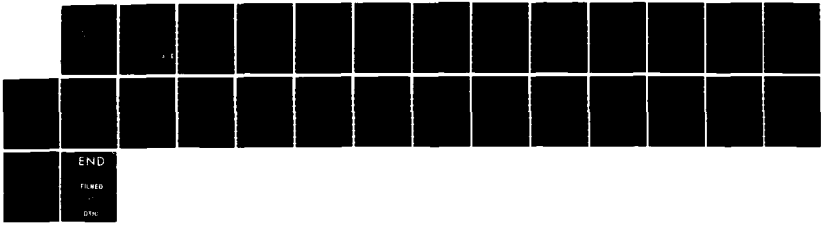

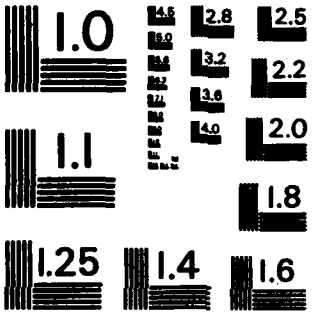

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

FINAL REPORT

MINI-CONFERENCE ON ORDER RESTRICTED INFERENCE

held on the

University of Iowa Campus

September 11, 12, 13, 1985

Richard Dykstra
Tim Robertson

This work relates to Department of Navy Grant N00014-85-G-0161 issued by the Office of Naval Research. The United States Government has a royalty-free license throughout the world in all copyrightable material contained herein.

This report contains a list of participants and abstracts of some of the 20 papers which were presented.

ABSTRACT

A miniconference on the topic of Order Restricted Inference was held on the University of Iowa campus during the days of September 11, 12, and 13, 1985. The conference was supported by a grant from the Office of Naval Research and the University of Iowa. The conference consisted of twenty presentations on a wide variety of topics dealing with Order Restricted Inference. There were approximately 35 conference participants coming from a wide variety of backgrounds and locations.

The majority of papers presented at the conference are currently being organized to appear in a Conference Proceedings Volume to be published by Springer-Verlag during the summer of 1986.

Keywords: Order Restricted Inference; Statistical Inference; Estimation; Hypothesis Testing; Optimality; Constraints; Dose-Response Curves; Power Functions.

CONFERENCE SUMMARY

The Office of Naval Research issued Grant No. N00014-G-0161 for the purpose of holding a miniconference on the topic of order restricted inference. This conference was held in the Iowa Memorial Union on the University of Iowa campus on September 11, 12, and 13, 1985. There were approximately thirty-five participants at the conference and the program consisted of twenty presentations. Enclosed is a list of participants for the conference, a copy of the program of the conference, and a partial list of abstracts for the presentations given. Funds from the Office of Naval Research grant were used primarily to support travel and subsistence of twenty-one of the participants.

We feel the conference was an unqualified success and we have received numerous favorable comments from the participants. Many of the participants indicated that if a similar such conference is to be held in the future, they would wish to attend. (A similar conference on the same topic was held at the University of Iowa in the spring of 1981 with support from ONR.) The tone of the conference was enthusiastic, and the interaction between participants was outstanding.

It has been decided to publish a Conference Proceedings which will include many of the best papers of the conference. With this in mind, we contacted several publishing concerns incuding Marcel Dekker, Springer-Verlag, Academic Press, and the IMS Lecture Note Series to see if they would have an interest in such a publication. The response of the publishing concerns was positive, and we have decided to accept an offer by Springer-Verlag to produce such a Proceedings. We anticipate that this volume will be available during the late summer of 1986.

SUMMARY BUDGET STATEMENT

ORDER RESTRICTED INFERENCE CONFERENCE

Supported by ONR Grant No. N00014-85-G-0161

TRAVEL AND SUBSISTENCE FOR PARTICIPANTS

Professor S. C. Kochar	$ 636.58
Professor A. Sen Gupta	250.53
Professor H. Mukerjee	382.48
Professor A. Sofer	531.72
Professor J. Pang	440.00
Professor R. Berger	533.55
Professor A. Agresti	699.02
Professor P. Laud	190.32
Professor S. Sukhatme	109.28
Professor D. Miller	545.90
Professor F. T. Wright	269.00
Professor G. Warrack	293.00
Professor T. San Lee	113.00
Professor B. Singh	398.00
Professor M. Schell	369.00
Professor S. Leurgans	137.40
Professor J. Hewett	14.76
Professor C. C. Lee	879.20
Professor T. Sager	333.45
Professor A. Fink	122.17
Professor Z. Govindarajulu	469.52
TOTAL TRAVEL AND SUBSISTENCE	$7717.88
CONFERENCE FACILITIES (Iowa Memorial Union)	$ 526.00
CONFERENCE DINNER (Ox Yoke Inn, Amana)	$ 342.85
MISCELLANEOUS	$ 35.96
TOTAL EXPENSES	$8622.72
ONR GRANT AMOUNT	$8500.00

(Difference will be paid by Department of
Statistics and Acturarial Science, Univ. of Iowa)

ORDER RESTRICTED INFERENCE CONFERENCE

September 11 - 13, 1985

Iowa Memorial Union - University of Iowa at Iowa City

Sponsored by Office of Naval Research and the University of Iowa

(In case of multiple authorship, an * indicates the speaker.)

Tuesday, September 10, 1985 (Iowa Memorial Union)

8:00 p.m. Triangle Club Lounge - Informal Mixer

Wednesday, September 11, 1985 (Michigan Room, IMU)

8:00 - Registration

8:15 - Opening remarks: John Birch, Chairman, Dept. of Statistics & Actuarial Science & Richard D. Remington, Vice President, Academic Affairs, University of Iowa

SESSION I: 8:30 - 10:20 Chaired by John Hewett, University of Missouri at Columbia

8:30 - 9:00 A Class of Distribution - Free Tests for Testing Homogeneity of Scale Against Ordered Alternatives
R.P. Gupta & Subbash C. Kochar*
Dalhousie University, Halifax, N.S.

9:10 - 9:40 Robustness of Chi-bar-square and E-bar-square with Ranked and Unranked Data.
Michael Schell*, St. Jude's Childrens Research Hospital
Bahadur Singh, Memphis State University

9:50 - 10:20 Conditional Tests with an Order Restriction as a Null Hypothesis
Peter Wollan*, Michigan Technological Univ.
Richard Dykstra, University of Iowa

10:20 - 10:50 BREAK

SESSION II: 10:50 - 12:00 Chaired by Peter Wollan, Michigan Technological Univ., Houghton

10:50 - 11:20 On Testing Symmetry and Unimodality
Tim Robertson, University of Iowa

11:20 - 11:50 Testing Hypotheses under Order Restrictions from a Bayesian Viewpoint
Bahadur Singh, Memphis State University

12:00 - 1:30 LUNCH

SESSION III: 1:30 - 4:20 Chaired by Michael Schell
St. Jude Children's Research Hospital

1:30 - 2:10 Power Series Approximations to the Distribution of Chi-bar-square and E-bar-square
Bahadur Singh, Memphis State University
F.T. Wright*, University of Missouri at Rolla

2:20 - 3:00 Multiple Comparison of Several Treatments with a Control Using the Maximum of Orthogonal Contrasts
Hari Mukerjee*, University of California-Davis
Tim Robertson, University of Iowa
F.T. Wright, University of Missouri-Rolla

3:00 - 3:30 BREAK

3:30 - 4:10 Applications of Isotonic Regression to Multivariate Density Estimation
Tom Sager, University of Texas at Austin

8:00 p.m. Beer Party Dykstra and Robertson (details later)

Thursday, September 12, 1985 (Michigan Room, IMU)

SESSION IV 8:30 - 10:20 Chaired by Robert Hogg
University of Iowa

8:30 - 9:00 Hypothesis Tests for Normal Means Constrained by Linear Inequalities
Richard Raubertas, National Institute of Health
Chu-In Charles Lee*, Memorial Univ. of Newfoundland
Erik Nordheim, University of Wisconsin

9:10 - 9:40 Constrained Optimization in Hilbert Space with Applications to Restricted Cubic Splines
James Boyle* and Richard Dykstra
University of Iowa

9:50 - 10:20 Completely Monotone Regression Estimates
Douglas Miller, George Washington University

10:20 - 10:50 BREAK

SESSION V 10:50 - 12:00 Chaired by Hari Mukerjee
University of California at Davis

10:50 - 11:20 Isotonic M-Estimation
Sue Leurgans, Ohio State University

11:20 - 11:50 Imputing Missing Data Under the Assumption of Positive Association
Jon Lemke, Dept. of Medicine, University of Iowa

12:00 - 1:30 LUNCH

SESSION VI 1:30 - 4:20 Chaired by Ralph Russo
University of Iowa

1:30 - 2:10 Directed Divergence Tests for Order Restrictions in a Multinomial Setting
Richard Dykstra, University of Iowa

2:20 - 3:00 Testing Whether a Set of Normal Means are in a Specified Order
Roger L. Berger, North Carolina State University

3:00 - 3:30 BREAK

3:30 - 4:10 Order Restricted Score Parameters in Association Models for Contingency Tables
Alan Agresti, University of Florida

6:30 - Dinner at the Amana Colonies
(Ox Yoke Inn, Amana)

Friday, September 13, 1985 (Michigan Room, IMU)

SESSION VII 8:30 - 10:20 Chaired by Carolyn Pillers
University of Iowa

8:30 - 9:00 Giles Warrack
University of North Carolina at Greensboro

9:10 - 9:40 An Asymptotically Distribution Free Test for Ordered Alternatives in a 2-Way Layout
Z. Govindarajulu*, University of Kentucky
S.H. Mansouri-Ghiassi, University of Kentucky

9:50 - 10:20 BREAK

10:20 - 10:50 Dose Response Analysis Under Unimodality of Response-to-Dose
Richard Schmoyer, Oak Ridge National Laboratory

SESSION VIII 10:50 - 12:00 Chaired by F.T. Wright
University of Missouri at Rolla

10:50 - 11:20 Ashis Sengupta, University of Wisconsin

ORDER RESTRICTED INFERENCE CONFERENCE

Participant List

September 11 - 13, 1985

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Louisiana State University

Carol Feltz
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AT & T

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Douglas Miller
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George Washington University

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Jong-Shi Pang
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University of Texas at Dallas

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Memphis State University

Ariela Sofer
System Engineering Dept.
George Mason University

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University of North Carolina

Peter Wollan
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Michigan Technological Univ.

F.T. Wright
Department of Mathematics
University of Missouri-Rolla

Shashikala Sukhatme
Department of Statistics
Iowa State University

A.M. Fink
Department of Mathematics
Iowa State University

Testing Whether a Set of Normal Means Satisy a Partial Order

Roger L. Berger
North Carolina State University

Let $\mu_1,\ldots,\mu_k$ denote k normal means. Robertson and Wegman (1978, Annals of Statistics) consider testing the null hypothesis H_1: $(\mu_1,\ldots,\mu_k)$ is isotone with respect to a specified partial order versus the alternative H_2: not H_1. In this paper the likelihood ratio test (LRT) for the problem of testing the null hypothesis H_2 versus the alternative H_1 is discussed. If one wishes to particularly guard against deciding the means are ordered, when they are not, our formulation may be preferable to Robertson and Wegman's. The LRT we obtain is quite different from Robertson and Wegman's. Our test statistic is a minimum of t-statistics and the critical values for our test are central t-distribution percentiles. Also the least favorable configuration in our problem is not the configuration in which all the means are equal.

Testing Homogeneity of Means Against The Alternative of Simple Order From A Bayesian Viewpoint

Bahadur Singh
Memphis State University

Assume the $\{Y_{ij} ; j = 1, \ldots, n\}$ for $i = 1,2,\ldots, k$ are k independent random samples from the normally distributed population with mean μ_i and common variance σ^2. It is desired to test the null hyposthesis Ho: $\mu_1 = \mu_2 = \ldots = \mu_k$ against the alternative hypothesis of simple order H_1: $\mu_1 < \mu_2 < \ldots < \mu_k$ with at least one strict inequality. Letting $\theta_i = \mu_{i+1} - \mu_i$ $(i = 1, 2, \ldots, d-1)$, and assuming independent, noninformative prior distributions on the unknown parameters, the postierior distribution of $\underset{\sim}{\theta} = (\theta_1, \ldots, \theta_{k-1})$ is obtained for the two cases of known and unknown σ^2. In the notation described above, testing H_o versus $H_1 - H_o$ is equivalent to testing the null hypostesis K_o: $\theta_1 = \theta_2 = \ldots = \theta_{k-1} = 0$ versus the alternative hyposthesis K_1: $\theta_i > 0$ for some $(i = 1,2,\ldots, k-1)$. An approximate and asymptotic chisquare test statistic is derived for testing K_o versus K_1 when is σ^2 known, while an approximate and asymptotic F test statistic is derived for testing K_o versus K_1 when σ^2 is unknown. The Bayesian test procedures are developed using the concept of the highest posterior desity regions.

Robustness of $\bar{\chi}^2$ - Like and $\bar{E}^2$ - Like Statistics with Respect to Departures from Normality

Michael J. Schell and Bahadur Singh
St Jude Children's Research Hospital

Let $\{ \chi_{ij}: i=1,\ldots,k; j=1,\ldots,n\}$ be k independent random samples of size n with means μ_i and common variance σ^2. It is desired to have tests for $H_0: \mu_1 = \mu_2 = \ldots = \mu_k$, versus the alternative of simple order $H_1: \mu_1 \leq \ldots \leq \mu_k$, with at least one strict inequality and H_1 versus $H_2: \mu_i > \mu_{i+1}$ for some i. When the k populations are normal, the likelihood ratio statistics are T_{01} and T_{12} when σ^2 is known and S_{01} and S_{12} when σ^2 is unknown. T_{01} and S_{01} are commonly known as chi-bar-square and E-bar-square, respectively. Using simulations methods, this paper assesses the robustness of the significance levels of these tests when the k populations are non-normal. The distributions used are the uniform, the double exponential, the t with 3 degrees of freedom and mixtures of normals. In addition, estimates for the power functions of the selected non-normal distributions are compared to the corresponding power function based on an underlying normal distribution.

Dose-Response Analysis Under Unimodality of Response-to-Dose

Richard L. Schmoyer
Oak Ridge National Laboratory

A dose-response curve π is sigmoidal if it is nondecreasing and there is a point M to the left of which π is convex and to the right of which π is concave. If π is sigmoidal, then the response-to-dose ratio $\pi(x)/x$ is unimodal and maximized at a point $H \geq M$. If $\pi(0)$ is known, if H is known, and if $x_0 \leq x \leq H$, then an upper confidence bound (UCB) for $\pi(x_0)$ can be constructed from a UCB for $\pi(x)$. Unfortunately, H is seldom known in practice. In the setting of quantal bioassay, two lower confidence bounds for H and corresponding UCB's for $\pi(x_0)$ when H is unknown are obtained and contrasted. One is based on a likelihood-ratio statistic; the other on a weighted sum of constraint contrasts. A maximum-violator algorithm with guaranteed convergence is given for computing the maximum likelihood estimates of the response probabilities subject to unimodality of $\pi(x)/x$.

Keywords: accelerated testing; linear interpolation; quantal bioassay.

Conditional Tests with an Order Restriction as a Null Hypothesis

Peter C. Wollan and Richard L. Dykstra
Michigan Technological University & University of Iowa

For the isotonic normal means problem, Bartholomew (1961) discussed a conditional likelihood-ratio test of H_o: the means are homogeneous, vs. H_1: the means satisy the linear order. He concluded that the conditional test was substantialy less powerful than the chi-bar-squared test. However, for testing H_1 vs. H_2: all alternatives, the corresponding conditional test can be more powerful than the chi-bar-squared test. Moreover, the conditional test can be modified so as to be asymptotically similar.

These conditional tests are of particular interest in general tests of simultaneous inequality constraints on parameters of asymptotically normal distributions, for which the coefficients corresponding to the p(l,k)'s are difficult to obtain. In this general context, the likelihood ratio statistic is asymptotically chi-bar-squared whenever the true parameter vector lies in H_1; we outline a new proof based on Silvey's theorem that a constrained estimate and its corresponding vector of Lagrange multipliers are asympototically normal and independent.

Statistical Inference Under Complete Monotonicity Restrictions

Douglas R. Miller and Ariela Sofer
The George Washington Univ. & George Mason Univ.

A completely monotone function is a function which has nonnegative even-numbered derivatives, and nonpositive odd-numbered derivatives. In this paper we address the problem of regression under the restrictions of complete monotonicity. These problems may arise in various applications and one such application in software reliability is described.

The paper discusses some of the numerical difficulties associated with these problems. In constrast to isotone regression, where the pool adjacent violators algorithm solves the problem in a finite number of simple steps, there is no simple finite algorithm for solving weighted least squares when the additional constraints of isotone (or antitone) higher derivatives (up to some maximal order) are imposed. We show, that, as the problem size and the maximal order of derivatives considered grow, the problem becomes increasingly ill-conditioned. The various difficulties which may arise are presented, and the performance of various numerical algorithms discussed.

Power Series Approximations to the Null Distributions in Order Inference: The case of Unequal Weights

Bahadur Singh and F. T. Wright
Memphis State University & University of Missouri-Rolla

Bartholomew's statistics for testing homogeneity of normal means with ordered alternatives have null distributions which are mixtures of chi-squared or beta distributions depending on whether the variances are known or not. If the ratio of sample sizes to the variances are not equal, the mixing coefficients can be difficult if not impossible to compute. Approximations to the significance levels of these tests have been developed for the total order and simple tree restrictions. However, for a moderate or large number of means, these approximations can be tedious to implement. Two and four-moment expansions in terms of Laguerre and Jacobi polynomials are developed to facilitate the use of these approximations. Approximate significance levels are also developed for the testing situation in which the order restriction is the null hypothesis. Numerical studies show that in each of the cases the two-moment approximation is quite satisfactory.

Bayes and Maximum Likelihood Order-Restricted Inference for Models for Ordinal Categorical Data

Alan Agresti
Department of Statistics
University of Florida

A class of association models for contingency tables has parameters that can be interpreted as category scores. For classifications having ordered categories, it is often reasonable to assume that the score parameters have a corresponding ordering. This article proposes order-restricted estimates of score parameters in these models. For these estimates, the local log odds ratios have uniform sign. Two solutions are given. For the maximum likelihood solution, goodness-of-fit statistics are related to statistics for collapsed tables and to statistics for testing equality of score parameters. For the Bayes solution, prior distributions induce the order restriction, and prior beliefs reflecting strong association have the effect of moving the estimates away from the boundary of the restricted parameter space.

Imputing Missing Categorical Data under the Assumption of Positive Association

Jon H. Lemke and Gregg A. Drube
University of Iowa

Imputation classes are subpopulations of a surveyed population for which one is willing to make the assumptions that item nonresponse occurs at random, even though the data cannot be assumed to be missing at random for the entire population. For the cross-classification of ordinal categorial variables, we demonstrate how the iterative-incremental algorithm of Lemke and Dykstra (1984) can be used as the M-step of the EM-algorithm to obtain maximum likelihood estimates of the cell probabilities within imputation classes under multiple closed convex cone restrictions. These order restrictions can be either on the logarithms of the cell probabilities or simply on the cell probabilities. The specific application for this presentation is the restriction that the local odds ratios are all at least one for the cross-classification of two ordinal response variables, that is, we are assuming that within each imputation class there is a positive association between the two response variables.

Shrinkage Estimates in Isotonic Regression

A. G. Warrack

When estimating a set of means from k independent normal populations, the techniques of isotonic regression may be used if it is known that the means satisfy a partial order. If the partial order happens to be a simple order, the isotonic estimate of the means has the desirable property that its expected mean square error is less than the unrestricted maximum likelihood estimate, and this property holds not only overall, i.e. when summed over all k populations, but also pointwise, for each of the k estimates.

However, the isotonic estimates, particularily those of the largest and smallest population means, are biased. In an effort to reduce this bias, shrinkage techniques, as developed by Stein and James, are investigated, and various "shrunken" isotonic estimates are compared with the regular isotonic estimates.

While these estimates do not remove the bias from the regular isotomic estimates, Monte Carlo results are presented to indicate that the overall mean square error of the isotomic estimates can be reduced by shrinkage techniques, in some cases considerably so.

An asymptotically distribution-free test for ordered alternatives in two-way layouts

Z. Govindarajulu and S.H. Mansouri-Ghiassi
University of Kentucky

An asymptotically distribution-free test is proposed for unequally spaced ordered alternatives in two-way layouts. The test statistic is a linear function of the ranks of residuals when the nuisance parameters are estimated. We show that the limiting distribution of the test statistic, when properly standardized, is normal. The asymptotic relative efficiency comparisons (in Pitman sense) with respect to the likelihood derivative test and nonparametric tests for randomized complete blocks show that our procedure is generally more powerful.

An Approach to Fitting Convex Interpolating and Smoothing Cubic Splines

Pat Boyle and Richard Dykstra
University of Iowa

Often it is desirable to find solutions to infinite dimensional optimization problems which have an infinite number of constraints. An algorithm developed by Dykstra (1983) is described and shown to be useful in determining convex interpolating and smoothing functions as solutions to such problems. Some numerical results are presented based upon APL routines that were written to obtain the convex smoothing functions. Finally, some concluding observations and conjectures are offered.

Applications of Isotonic Regression to Multivariate Density Estimation

Thomas W. Sager
Center for Statistical Sciences
The University of Texas at Austin

Unrestricted nonparametric multivariate density estimation suffers from difficult convergence and computational problems. One way to overcome these problems is to exploit presumed or estimated structure in the density. The isopleth density estimator presumes or estimates the structure of the contours of the density to effectively reduce the dimensionality. The estimator incorporates an order-preserving algorithm to insure that higher isopleths have higher density estimates than lower isopleths. Convergence properties and stimulations are presented. The importance of edge effects is also noted.

Isotonic M-Estimation

Sue Leurgans
The Ohio State University

The isotonic regression of Y on x is the isotonic function of x which minimizes the error sum of squares. For linear models, studies of robustness properties have shown that the use of other criterion functions is valuable in practice. One large class of other alternative criterion functions gives M-estimators. Magel and Wright (1984) demonstrate that analogous benefits can be obtained for isotonic regression. In this paper, several recursive-partitioning algorithms which are valid for the regular least squares problems do not apply to all M-estimation problems, even those based on estimators with monotone influence functions. Through examples, isotonic M-estimators are shown to implicitly balance the order information supplied by a data point against the size of the residual generated by the point.

Tests for Generalized Variances Under Order Restrictions

Ashis SenGupta
University of Wisconsin-Madison
Indian Statistical Institute

Let $X \sim N_p(0, \Sigma_p)$, $\Sigma_p = \rho E + (1 - \rho) I$, where E is a matrix with all elements equal to unity and I is the identity matrix. Tests for the Generalized Variance (Scatter Coefficient) $|\Sigma_p|$ for one and several independent populations are considered. These are developed using characterizations for conditional characteristic roots and the technique of isotonic regression. Applications include comparison of 'overall' scatter of several multi-dimensional populations and inferences in generalized canonical variables analyses.

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Richard Dykstra
Tim Robertson

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Order restricted conference, statistical inference, estimation, hypotheses testing, optimality, constraints, dose-response curves, power functions

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
A miniconference on the topic of Order Restricted Inference was held on the University of Iowa campus during the days of September 11, 12, and 13, 1985. The conference was supported by a grant from the Office of Naval Research and the University of Iowa. The conference consisted of twenty presentations on a wide variety of topics dealing with Order Restricted Inference. There were approximately 35 conference participants coming from a wide variety of backgrounds and locations.

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The majority of papers presented at the conference are currently being organized to appear in a Conference Proceedings Volume to be published by Springer-Verlag during the summer of 1986.

END

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